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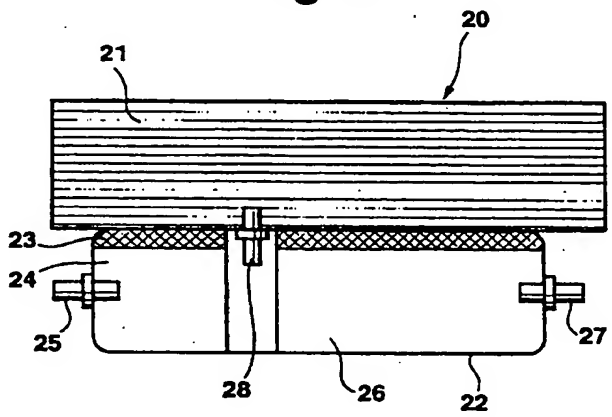
(54) Airbag safety system for vehicle passengers

(57) After activation of the airbag 21 the pressure characteristic inside the airbag is monitored by a pressure sensor 28. If the pressure characteristic conforms to that of unimpeded inflation of the airbag, then inflation continues as normal. However, if the pressure characteristic indicates impeded inflation, eg as a result of a front seat passenger leaning forwards or a child's seat being disposed on the front passenger seat, then inflation is suspended. As shown, the airbag is inflated in two stages by using two chambers 24, 26 containing propelling charges and two ignition elements 25, 27. The stages are triggered by an a.c. module (Fig 5). If impeded inflation is detected during the first stage inflation then the second stage inflation is prevented. Alternatively (Fig 6) a solenoid valve (60) is controlled by the pressure sensor so as to control the pressure supplied to the airbag from a pressure container (61).

Fig. 2



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Safety device for vehicle passengers

Background art

The invention proceeds from a safety device for vehicle passengers according to the type of claim 1. Such a safety device is known, for example, from US-PS 5,129,673 or from the bibliographical source 1141 Ingenieurs de l'Automobile (1982) No. 6, page 69 ff. Furthermore, from US-PS 5,411,289, a safety device of the specified type having airbags is known, in which in dependence upon the operating state of a safety belt the airbags, in particular the airbag provided for the front seat passenger, are inflatable in a different manner. From US-PS 5,118,134 it is further known to make the activation of a safety device of the specified type dependent upon the actual sitting position of a vehicle passenger in order to guarantee an optimum protective effect. Said safety device however requires the vehicle to be equipped with expensive sensors which are capable of detecting the actual sitting position of the vehicle passenger.

Advantages of the invention

In contrast, the invention in particular offers the advantage that the comfort and operational reliability of a safety device of the specified type may be further increased for a comparatively low additional technical outlay. Especially compared with known safety devices, in which a plurality of sensors are disposed inside the vehicle for detecting the sitting position of the vehicle passengers, a considerable simplification is provided which is combined with corresponding cost reductions. The critical problem that during the activating process of an airbag an obstacle is in the way, which could interfere with the unfolding process, is

solved in a simple manner in that the unfolding state of the airbag is monitored and compared with a setpoint value. An obstacle could be, for example, a vehicle passenger maintaining an unacceptable sitting position or a child's seat disposed on the front passenger seat. In such situations, the activation of an airbag is more likely to have adverse consequences so that an activation should rather not occur or the activation should be controlled in a particular manner. In a particularly simple manner, the unfolding state of the airbag may be monitored by measuring the pressure in the airbag and comparing said measured pressure with a setpoint pressure value. In the event of a variation from the predetermined setpoint value, the further unfolding of the airbag may be suspended. A road traffic vehicle is exposed to comparatively large fluctuations in temperature. The prevailing ambient temperature may therefore greatly influence the pressure value actually measured at any one time. In a further refinement of the invention it is therefore particularly advantageous to determine, instead of an absolute pressure value, the characteristic of pressure values as a function of time and preferably to derive from the latter the characteristic of the tangent to the pressure curve and compare the determined tangent shape with a predetermined setpoint value. In the event of a variation of the determined tangent shape from the setpoint value, influence may then be brought to bear once more upon the unfolding of the airbag. To enable optional multi-stage control of the unfolding of the airbag, it is advantageous to provide an at least two-stage gas generator, wherein after activation of the first stage of the gas generator further stages of the gas generator are activated only if the unfolding state of the airbag acted upon by the gas generator corresponds to a setpoint state. A particularly advantageous type of control during unfolding of the airbag is made possible by a pressure container which is filled with compressed gas and has, disposed in its supply line to the airbag module, a solenoid valve controllable by a control unit. The control unit monitors the unfolding process

of the activated airbag and in accordance with the unfolding process controls the solenoid valve in order to allow more or less gas to pass into the airbag. A multi-stage gas generator may be controlled in a particularly advantageous manner by means of a.c. ignition modules developed by the applicants. For said purpose, the a.c. ignition modules control ignition elements which are connected in series to capacitors. When differing capacitance values are provided for said capacitors and said ignition modules are acted upon by alternating current, there is automatically a time grading in the activation of the individual stages of a multi-stage gas generator. The achievable time grading may also be influenced by the dimensions of the components.

Drawings

Embodiments of the invention are illustrated in the drawings and explained in detail in the following description. Of the drawings, Figure 1 shows a safety device of the specified type in the form of a schematic block diagram, Figure 2 an airbag module, Figure 3 a first curve illustrating the pressure characteristic as a function of time, Figure 4 a second curve illustrating the pressure characteristic as a function of time, Figure 5 a block diagram of an ignition output module and Figure 6 a further embodiment of a safety device.

Description of the embodiments

Figure 1 shows a schematic block diagram of a safety device of the type described. Said device comprises at least one acceleration sensor 2, a control unit for evaluating the output signals of the acceleration sensor 2 and for activating a plurality of vehicle passenger security means 4a, 4b, 4c, such as airbags, belt tensioners and the like. To said end, the security means 4a, 4b, 4c are connected to at least one output connection of the control unit 3. When the output signal of the acceleration sensor 2 which is evaluated by the

control unit 3 indicates an accident situation, the control unit in dependence upon the occupation of the vehicle by passengers activates the security means 4a, 4b, 4c required to protect the respective vehicle passenger. Thus, for example, if the vehicle is occupied only by a driver, advantageously only the security means provided for the driver, such as a belt tensioner and/or airbag, are activated. Security means for vehicle passengers, such as a belt tensioner and/or airbag, have proved excellent in past years and nowadays are widely fitted as standard into vehicles. In many accident situations, the activation of said security means is desirable and necessary as said means provide additional safety for passengers and save lives. There are however also particularly critical situations where, compared to a normal state, differentiated methods of activating such security means have to be applied or it is even necessary to decide that the security means should not be activated at all. Particularly critical in said context is the sitting position of the passengers in a vehicle who, unlike the driver himself, have far greater freedom when it comes to selecting a sitting position which is acceptable to them. Here, even the adoption of a sitting position which is disadvantageous for the use of security means cannot be ruled out. For example, the front seat passenger may lean forward towards the glove compartment or to look for an article which has perhaps fallen down into the foot well. If at precisely said moment an airbag were activated, this could contribute towards putting the front seat passenger at greater risk. Also to be considered critical is the activation of an airbag provided for the front seat passenger when a child's seat is situated on the front passenger seat. In order to cope with said critical sitting positions and yet be able to use the life-saving security means it is already known to equip vehicles with an expensive sensor arrangement, which detects the actual sitting position of a vehicle passenger and, in dependence upon said sitting position, controls the activation of a security means. Equipping a vehicle with additional sensors in said manner

adds considerably to the cost of the vehicle as the sensors have to operate very reliably and there has to be a considerable outlay for the cabling of the sensors. In contrast, the invention in a comparatively simple and inexpensive yet reliable manner allows such special situations to be taken into account, namely in that the unfolding state of the airbag is monitored after activation and compared with a setpoint state. If the actually detected unfolding state differs from the setpoint state, a controlling intervention into the unfolding state is effected in that preferably further unfolding of the airbag is suspended. Monitoring of the unfolding state of an airbag is effected in a particularly simple and advantageous manner by measuring the pressure in an airbag module, such a process being described with reference to a first embodiment of the invention illustrated in Figure 2, Figure 3 and Figure 4. Figure 2 shows an airbag module denoted by reference numeral 20. Said airbag module 20 comprises an airbag 21 shown in its folded state and a gas generator 22 comprising a plurality of chambers 24, 26. Disposed in the separate chambers 24, 26 are pyrotechnic propelling charges which in each case, after ignition by ignition elements 25, 27 associated with each chamber 24, 26, develop large quantities of propellant gas which inflate the folded airbag 21 for the purpose of protecting the vehicle passenger. Disposed between the airbag 21 and the chambers 24, 26 there is additionally a filter 23 which is used to filter and cool the propellant gases generated by the gas generator 22. The construction of the airbag module 20 described above allows a separate activation of the chambers 24, 26 of the gas generator 22 so that a multi-stage activation of the gas generator 22 and hence also a graded-time development of propellant gas is achievable. Disposed inside the airbag module 20 is, moreover, a pressure sensor 28 enabling measurement of the gas pressure prevailing in the airbag 21. The measured gas pressure or the characteristic of the pressure curve p (t) as a function of time is indirectly a measure of the unfolding state of the airbag 21. By detecting

the pressure value inside the airbag 21 and comparing the detected pressure values with predetermined setpoint values it is therefore possible to draw conclusions about the unfolding state of the airbag 21. In said manner it is also possible to detect irregularities which arise, for example, as a result of the airbag 21 in the course of unfolding encountering an unexpected obstacle, e.g. a vehicle passenger sitting in a disadvantageous position. Should this occur, a controlling intervention into the unfolding state of the airbag 21 may be effected, a more thorough explanation of such a process being given in the following description of the mode of operation of the embodiment according to Figure 2 and also with the aid of the graphs according to Figure 3 and Figure 4.

An airbag module 20 comprising a multi-stage gas generator 22 (Figure 2) is activated when the acceleration sensor 2 produces an output signal indicating a critical accident situation, said output signal being evaluated by the control unit 3 and used to trigger the airbag module 20. Triggering is effected by activating the ignition elements 25, 27 associated with the chambers 24, 26. Advantageously, initially only one stage of the multi-stage gas generator 22 is ignited in that, for example, the ignition element 25 associated with the first chamber 24 is activated by the control unit 3. After activation of the ignition element 25, the propelling charge disposed in the first chamber 24 of the multi-stage gas generator 22 develops propellant gases which, after passing through the filter 23, enter the airbag 21, which in its position of rest is folded, and unfold said airbag. In the process, the airbag module 20, which is usually provided with a cover, tears open so that the airbag, as it continues to unfold, may unfold into the passenger area of the vehicle. During said process, the pressure sensor 28 disposed in the airbag 21 continuously measures pressure values. Displayed as a function of time t, the result is, for example, the pressure curve p (t) as a function of time t which is shown in Figure 3. The curve display shown in Figure

3 is characteristic of an unimpeded unfolding process of an airbag 21 upon ignition of the first stage of a multi-stage gas generator. At the time T1, a maximum value P1 of the pressure is reached. At said time, the cover of the airbag 21 tears open and the airbag, as it continues to unfold, spreads out into the passenger area of the vehicle for the purpose of protecting a vehicle passenger. So long as said pressure characteristic indicates a normal unfolding process of the airbag 21, the second stage of the gas generator 22 may then be additionally ignited by activating the ignition element associated with the second chamber 26 of the gas generator 22. Ignition of the second stage generates more propellant gases which effect the further unfolding of the airbag 21. If, however, the envelope of the unfolding airbag 21 then encounters an obstacle, e.g. a front seat passenger leaning forwards or a child's seat disposed on the front passenger seat, the shape of the pressure curve alters in a characteristic manner which is clearly evident from the graph in Figure 4. After ignition of the first stage of the multi-stage gas generator 22 (first chamber 24, ignition element 25), the pressure p (t) initially rises, in the manner already shown in Figure 3, to a first maximum P1 which is reached at the time T1. Once more, at said time, the cover of the airbag module 20 tears open. Subsequently, the pressure initially drops before then rising again to a further maximum value P2 which is reached at the time T2. Said second extreme value indicates that, at said time T, the outer envelope of the airbag 21 has collided with an obstacle which in a sustained manner is impeding further unfolding of the airbag. When said obstacle is detected by evaluation of the pressure characteristic, an initially provided ignition of the second stage of the multi-stage gas generator 22 may then be suspended so as to rule out, for example, the putting at risk of a vehicle passenger occupying a disadvantageous sitting position or a small child seated in a child's seat. As is known, road traffic vehicles are exposed to extreme variations of temperature. Said temperature variations also act upon the

components of the security system. It therefore has to be reckoned that, depending on the ambient temperature and in particular on the seasons, extreme variations arise in the pressure characteristic p (t). Instead of measuring selected pressure values P and comparing said values with setpoint values, it may therefore prove advantageous to determine a plurality of pressure values within a measuring interval and calculate from said pressure values the tangent or ascent values of the pressure curve p (t) as a function of time t. A comparison of said calculated values with predeterminable setpoint values again makes it possible to detect variations which indicate impeded unfolding of the air bag 21.

It is particularly advantageous if a multi-stage gas generator 22 is triggered by an a.c. output module, which has been developed by the applicants and the schematic structure of which is illustrated in Figure 5. Said a.c. output module 50 preferably forms part of the control unit 3 illustrated in Figure 1. Said a.c. output module 50 is used to activate ignition elements 51a, 51b which are connected in series to capacitors 52a, 52b. Said capacitors have relatively no [sic] capacitance values. At any rate, the capacitance values of the capacitors 52a, 52b are so low that the charge stored at each of them is not enough to cause a current flow sufficient to activate the ignition elements 51a, 51b. Only a repeated charging and discharging of the capacitors 52a, 52b leads to a suitable current through the ignition elements 51a, 51b. The capacitance values of the capacitors 52a, 52b are advantageously of differing dimensions. The effect thereby achieved is a graded-time activation of the ignition elements 51a, 51b. In said manner, a multi-stage gas generator may advantageously be controlled in such a way that initially the first stage of the multi-stage gas generator is ignited and then, after a suitable time delay, the second stage of the multi-stage gas generator.

A further embodiment of the invention is described with reference to Figure 6. Instead of a multi-stage gas generator, said embodiment comprises a pressure container 61 for a highly pressurized gas such as, for example, nitrogen. Said pressure container 61 is connected by a line, a solenoid valve 60 and a further line 63 to the airbag module 20. The solenoid valve comprises an actuator 60b and a solenoid 60a, which operates said actuator 60b and is activated by the control unit 3 (cf. Figure 1). In accordance with the pressure p (t) detected by the pressure sensor 28 inside the airbag 21, the control unit 3 operates the solenoid valve 60 so that the airbag 21 may be acted upon to a greater or lesser extent by gas from the pressure container 61. With said embodiment, an even more sensitive unfolding of the airbag 21 is possible because a particularly finely graded gas supply may be effected.

Claims

1. Safety device for vehicle passengers, having at least one acceleration sensor, having means of evaluating the output signals of the acceleration sensor and activating security means for vehicle passengers such as a belt tensioner and/or airbag, characterized in that, after activation of the airbag (21), the unfolding state of the airbag is monitored and compared with a setpoint value, and that in the event of a variation from the setpoint value the further unfolding of the airbag (21) is suspended.

2. Safety device according to claim 1, characterized in that the pressure (p (t)) prevailing in the airbag (21) is measured and compared with a setpoint pressure value, and that in the event of a variation from the setpoint value the further unfolding of the airbag is suspended.

3. Safety device according to claim 2, characterized in that the pressure prevailing in the airbag is measured, that from the measured pressure values the rise of the curve p (t) [sic] and that in the event of a variation of the determined rise from a predetermined rise the further unfolding of the airbag is suspended.

4. Safety device for vehicle passengers according to one of claims 1 to 3, characterized in that an airbag module (20) is provided with an at least two-stage gas generator (22) and that, after activation of the first stage (23, 24, 25) of the gas generator (22), further stages (23, 26, 27) of the gas generator are activated only when the

unfolding state of the airbag (21) acted upon by the gas generator (22) corresponds to a predeterminable setpoint value.

5. Safety device according to one of claims 1 to 4, characterized in that a compressed gas container (61) is provided for the purpose of admitting compressed gas into the airbag (21) of an airbag module (20), and that a solenoid valve (60, 60a, 60b) disposed between the compressed gas container (61) and the airbag module (20) is further provided for controlling the supply of compressed gas to the airbag (21), the solenoid valve (60, 60a, 60b) being controllable by the control unit (3) in dependence upon the output signal of a pressure sensor (28).

6. A safety device substantially as herein described with reference to Figures 1 to 5 or Figure 6 of the accompanying drawings.

The Patent Office

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Application N : GB 9614939.8 **Examiner:** David Summerhayes
Claims searched: 1-6 **Date of search:** 1 October 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G4N (NHVSC)

Int Cl (Ed.6): B60R 21/00

Other: ONLINE: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB1333269	(TOYOTA)	1 at least
X	US5295712	(OMURA) - see particularly col.7, lines 54-64	1 at least
X	US5184845	(OMURA) - see particularly col.7, lines 23-58	1 at least
X	US4213635	(INOKUCHI)	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Fig. 1

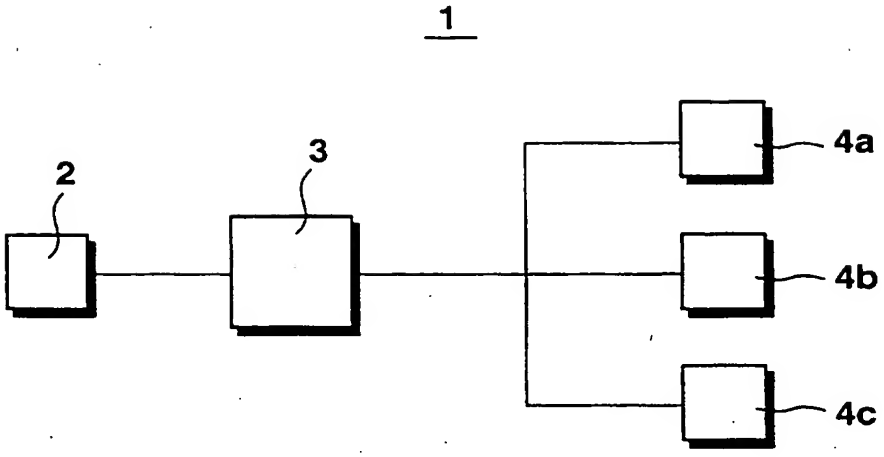

Fig. 2

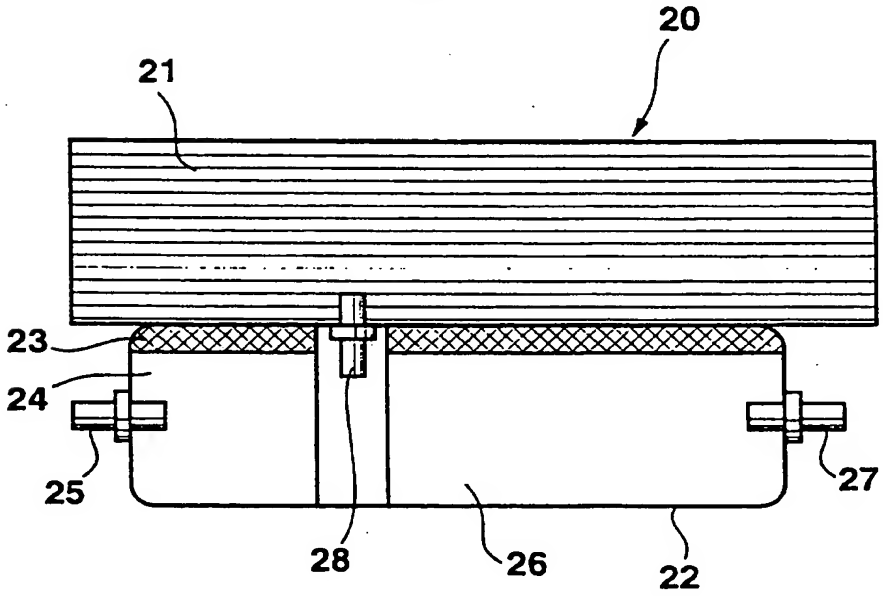

Fig. 3

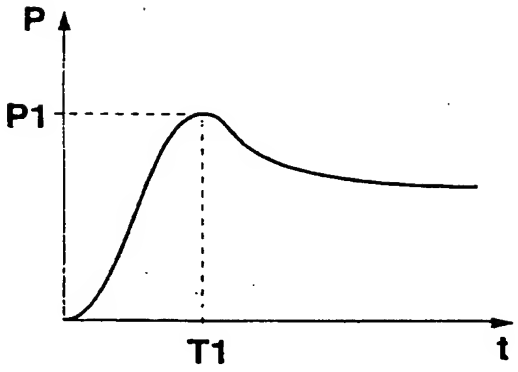

Fig. 4

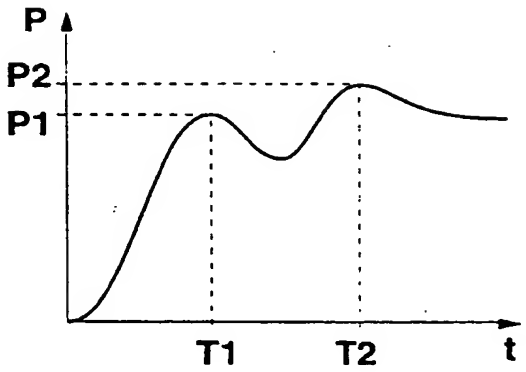

Fig. 5

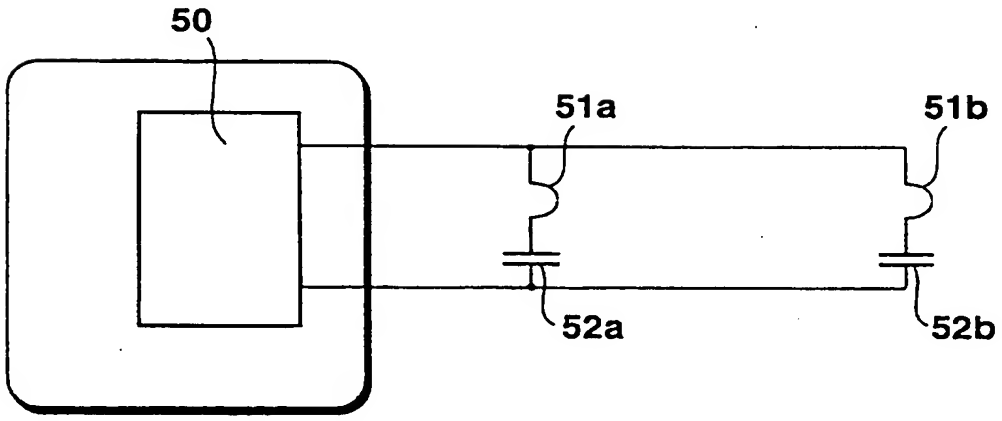

Fig. 6